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Research Note

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Density and Age Affect Performance of Containerized Loblolly Pine Seedlings

James P. Barnett

SUMMARY

Loblolly pine seedlings were grown in 1 × 5 inch biodegradable plastic tubes for 10, 12, and 14 weeks at densities of 42, 84, 126, and 168 per square foot. Seedling density and age significantly affected seedling development at time of outplanting, and density became more important as greenhouse growing times increased. All morphological characteristics measured when seedlings were planted—height, diameters, root and shoot dry weights, and proportion of seedlings with secondary needles—were correlated significantly with field survival, height, and growth. Stem dry weights were most closely related to field performance. Best seedling development and performance were obtained at the lowest seedling density.

Additional keywords: *Pinus taeda*, seedling development, seedling survival, seedling physiology, seedling morphology.

INTRODUCTION

Low seedbed densities in bare-root nurseries improve early height growth of southern pines after outplanting (Shipman 1966, Switzer and Nelson 1963). Few studies have tested density where other factors such as container volume remain constant (Hocking and Mitchell 1975).

The work of Tanaka and Timmis (1974) with Douglas-fir and Harris et al. (1972) with several hardwoods shows that density in containers can influence seedling morphology. Generally, low densities produce shorter, thicker-stemmed plants with greater shoot and root dry weights and more cold-hardiness. This study determined how loblolly pine in containers responded to various spacings and how seedling age influenced development at these spacings.

MATERIALS AND METHODS

Stratified loblolly pine seeds from a central Louisiana source were sown into biodegradable polycaprolactone tubes (Clendinning et al. 1974) containing a commercial potting medium of peat and vermiculite. The hexagonal tubes were about 1 inch in diameter by about 5 inches long. Densities tested were 168, 126, 84, and 42 tubes per square foot. Tubes rested against one another at 168/ft². At lower densities, vermiculite was used to fill spaces and maintain proper distances among tubes. Seeds were sown every 2 weeks so that seedling ages of 10, 12, and 14 weeks were available for field planting. Treatments were replicated five times in a completely randomized design.

Southern Forest Experiment Station/T-10210 U.S. Postal Services Bldg., 701 Loyola Avenue, New Orleans, La. 70113
Forest Service, U.S. Department of Agriculture.
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From about 3 weeks after sowing, seedlings were watered to saturation weekly with a water soluble nutrient solution (NPK 20-19-18). The greenhouse was under natural photoperiod, and temperatures were 24° C ± 4° during the growing period.

Seedlings heights, diameters at ground line, shoot and root dry weights, and proportion of seedlings with secondary needles were measured on five seedlings from each replication when seedlings were planted. Planting was done on a moderately drained silt-loam soil that had been disked earlier. Seedlings were planted June 28, 1976, after a 1.8 inch rain, and 6.6 inches of rain fell during the next 2 months, 2.2 inches less than normal. Field survival was determined 2 months after planting. Survival and heights were measured in the fall dormant season and again 1 and 2 years later. Correlation coefficients were computed so morphological characteristics could be related to field performance. Level of probability was 0.05.

RESULTS AND DISCUSSION

Initial Seedling Development

Generally, measured characteristics increased with increasing age and decreasing density (table 1). But how much seedling density affected these characteristics varied with age. Differences due to seedling density were much greater at 12 and 14 weeks of age than at 10 weeks.

Field Survival

Two months after outplanting, survival averaged 94 percent for all treatments. Even with this high survival, seedling density in the greenhouse significantly affected field performance. Seedlings of all ages grown at 42/ft² survived better than those grown at 126 or 168/ft² (table 2). Survival trends were similar in February 1977, 1978, and 1979. In February 1979, seedlings grown at 42/ft² averaged 96 percent survival, but those grown at 168/ft² had only 85 percent survival.

Although seedling age did not affect field survival initially or after one complete growing season in the field, significant differences did occur in February 1978 and 1979. Seedlings planted at 10 weeks had 86 percent survival, but 12-week seedlings had 92 percent and 14-week seedlings had 93 percent by February 1979. Apparently the smaller seedlings were not able to compete as well as larger seedlings with surrounding vegetation.

Heights

Seedling heights were closely related to condition of seedlings when they were planted. Seedlings grown for 12 and 14 weeks at low densities were taller in the field than were seedlings grown 10 weeks at the low densities (table 3).

In February 1979, about 2½ years after outplanting, seedlings planted after 14 weeks at 42/ft² were over 1 ft taller than those grown 14 weeks at 168/ft². But density of seedlings planted at 10 weeks of age had little effect on heights. Only 0.15-ft difference in height was evident among 10-week seedlings after 2½ years.

Growth

Amount of growth during the 1977 and 1978 growing seasons shows that density and age treatments continue to affect field performance after planting (table 4). During the 1978 season, larger seedlings from the 42/ft² density and the 12- and 14-week growing periods maintained growth of 1/2 foot more than other age-density treatments.

Correlations With Field Performance

Correlation coefficients (table 5) show that all initial seedling characteristics measured were significantly related to field survival, heights, and growth. Coefficients between seedling characteristics and survival increased as field exposure lengthened; for example, stem weight at 2 months after outplanting had a coefficient of 0.67, but this had increased to 0.84 when survival was measured 2½ years later. This increase in correlation reflects losses of small, weak seedlings that survived early but then could not compete successfully. Stem weight was the characteristic most closely related to survival. Height and diameter were significantly related to survival but had the lowest correlations of characteristics

James P. Barnett is Principal Silviculturist, Southern Forest Experiment Station, Forest Service—USDA, Pineville, Louisiana.

Table 1.—*Average characteristics of loblolly pine seedlings grown under greenhouse conditions at varying ages and densities*

Seedling age	Seedling density	Seedling Characteristics				
		Height	Stem diameter	Root weight	Stem weight	Secondary needles
Weeks	*No./ft.²*	*------Millimeter------*		*-----Milligram-----*		*Percent*
10	168	72	.9	16	68	10
	126	58	.8	14	62	5
	84	91	1.4	37	142	65
	42	82	1.2	27	127	30
12	168	71	1.0	26	99	35
	126	108	1.4	46	200	75
	84	96	1.2	42	194	80
	42	118	1.5	49	301	100
14	168	121	1.2	23	162	75
	126	102	1.3	42	204	95
	84	121	1.3	57	253	95
	42	129	1.6	78	333	100

Table 2.—*Average field survival of loblolly pine seedlings grown under greenhouse conditions at varying ages and densities*

Seedling age	Seedling density	Field survival			
		2 mo.	Feb. 1977	Feb. 1978	Feb. 1979
Weeks	*No./ft²*	*----------Percent----------*			
10	168	90	89	88	86
	126	90	89	85	83
	84	90	89	82	81
	42	99	98	96	94
12	168	93	91	88	86
	126	95	95	94	92
	84	97	97	96	95
	42	98	98	98	97
14	168	88	87	86	84
	126	96	96	93	93
	84	98	98	98	98
	42	98	98	97	98

measured. This lower correlation was probably caused by densities at which seedlings grew.

Degree of association of seedling properties with heights decreased as time passed in the field (table 5). This decrease is logical because environment influences heights more the longer plants are in the field. Largest correlation coefficients occurred between stem weight and field height.

At the end of 1978, correlations continued to be strong between stem weight at outplanting and amount of growth, with a coefficient of 0.87. Coefficients of all other characteristics with stem weight were lower but still statistically significant.

RECOMMENDATIONS

As longer seedling culture periods are used, density becomes more important. Loblolly pine seedlings need to grow 12 to 14 weeks to be large enough to perform well in the field. With those cultural periods, which density is most economical is unclear. Such an analysis must wait for additional growth data. But densities should probably not exceed 100/ft^2. If cost of greenhouse space is ignored, 42/ft^2 seems best.

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Table 3.—*Average height of loblolly pine seedlings grown under greenhouse conditions at varying ages and densities*

Seedling age	Seedling density	Height		
		Feb. 1977	Feb. 1978	Feb. 1979
Weeks	*No./ft^2*	*Feet*		
10	168	0.33	1.41	2.59
	126	.34	1.35	2.48
	84	.34	1.35	2.36
	42	.39	1.52	2.74
12	168	.36	1.53	2.84
	126	.40	1.51	2.88
	84	.47	1.76	3.20
	42	.50	2.02	3.81
14	168	.42	1.50	2.76
	126	.45	1.52	2.82
	84	.52	1.84	3.47
	42	.59	2.14	3.81

Table 4.—*Growth of loblolly pine seedlings outplanted after development under greenhouse conditions at varying ages and densities*

Seedling age	Seedling density	Growth 1977	Growth 1978
Weeks	*No./ft²*	*Feet*	
10	168	1.07	1.19
	126	1.00	1.13
	84	1.01	1.01
	42	1.12	1.22
12	168	1.17	1.32
	126	1.10	1.37
	84	1.29	1.44
	42	1.52	1.78
14	168	1.08	1.26
	126	1.07	1.30
	84	1.32	1.63
	42	1.56	1.67

Table 5.—*Correlation coefficients relating seedling characteristics at time of planting to field performance*[1]

Seedling characteristics	Survival (%) 2 mo.	Feb. 1977	Feb. 1978	Feb. 1979	Height (ft) Feb. 1977	Feb. 1978	Feb. 1979	Growth (ft) 1977	1978
Height (mm)	.42	.48	.70	.60	.83	.77	.72	.64	.71
Diameter (mm)	.55	.59	.53	.59	.71	.73	.64	.62	.59
Root wt. (mg.)	.68	.72	.68	.76	.89	.85	.81	.78	.76
Stem wt. (mg)	.67	.72	.73	.84	.94	.91	.89	.85	.87
Sec. needles (%)	.51	.58	.57	.64	.82	.75	.71	.62	.72

[1] A correlation coefficient of 0.553 is necessary for statistical significance at the 0.05 level.